

on the power level that each system is operating at. STARSYS states <sup>3</sup> that its system will generate a PFD (Power Flux Density) at the Earth's surface of less than -150 dBW/m<sup>2</sup>/4kHz. In order to understand how much of the available capacity of the spectrum this amount of PFD will

[REDACTED]

The characteristic S-shaped curve of Figure A-2 illustrates that there is a finite spectrum capacity limit in a CDMA system, and the value of PFD that is equal to  $\rho_{nd}$  occurs always at the value of capacity that is half of the absolute maximum asymptotic value. The fact that STARSYS is operating at a PFD of around -150 dBW/m<sup>2</sup>/4kHz, which is significantly higher than  $\rho_{nd}$ , indicates that there is very little remaining capacity in the spectrum, either for use by STARSYS or any other new entrant.

In order to be able to accommodate a future entrant in the CDMA portion of the spectrum, it will be necessary to limit STARSYS to a value of PFD comparable to  $\rho_{nd}$ , which is -164 dBW/m<sup>2</sup>/4kHz. Operating at a lower point in the CDMA capacity S-curve would also increase the power efficiency of the STARSYS downlink significantly, albeit at somewhat reduced capacity. In addition it will be necessary to ensure that all systems accessing the same spectrum should use CDMA codes that are compatible. One way to ensure this is to constrain the first operator in the spectrum to use a code scheme that has a sufficient number of codes for all the eventual users sharing the spectrum, not just the users that belong to the initial system.

We next consider the possibility of a future entrant in the FDMA portion of the spectrum. From the initial bandwidth of 1000 kHz (137 - 138 MHz), the exclusion of the bandwidth utilized by the existing TIROS/METEOR system (128 kHz) and the bandwidth which is unavailable to MSS on a primary basis (325 kHz), leaves only 547 kHz of non-contiguous spectrum available for use by NVNG LEO MSS systems. Of this 547 kHz, ORBCOMM requires more than 320 kHz, leaving only 226 kHz of spectrum for future entrants. In practice

## 2.2 148 - 150.05 MHz Band

This band has been proposed to be used for the Earth-to-space feeder links of STARSYS (50 kHz) and ORBCOMM (50 kHz), and the Earth-to-space links of VITA (90 kHz). In addition the STARSYS mobile-to-satellite links are contained in a 855 kHz band that is foreseen to be dedicated to CDMA, and the corresponding ORBCOMM links in a separate 855 kHz band dedicated to FDMA systems. The 150 kHz band from 149.9-150.05 kHz (currently used by TRANSIT) is not expected to be occupied by the current applicants <sup>6</sup>. Figure A-3 shows the spectrum sharing plan for this frequency band as proposed by the current applicants.

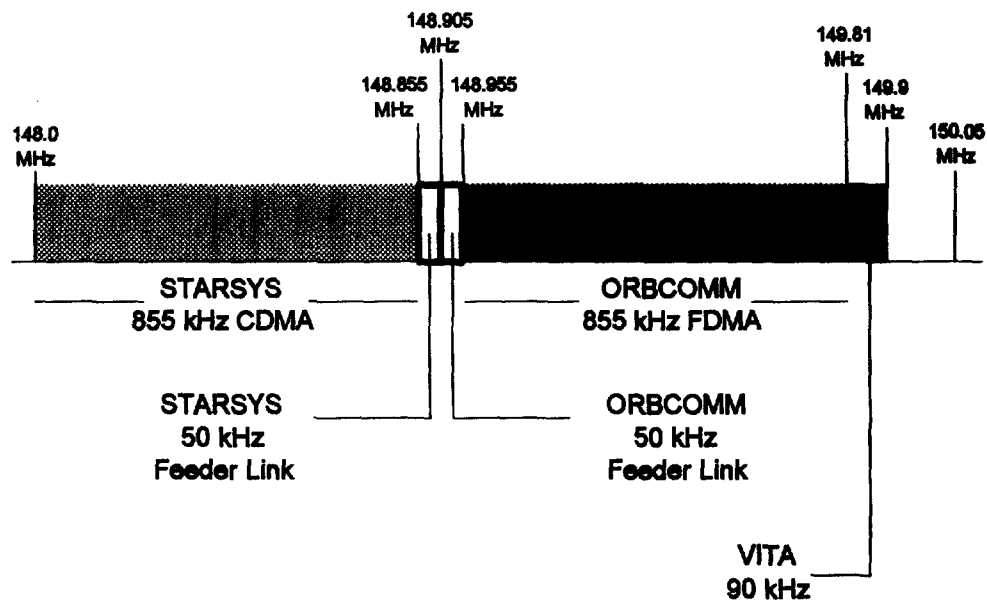
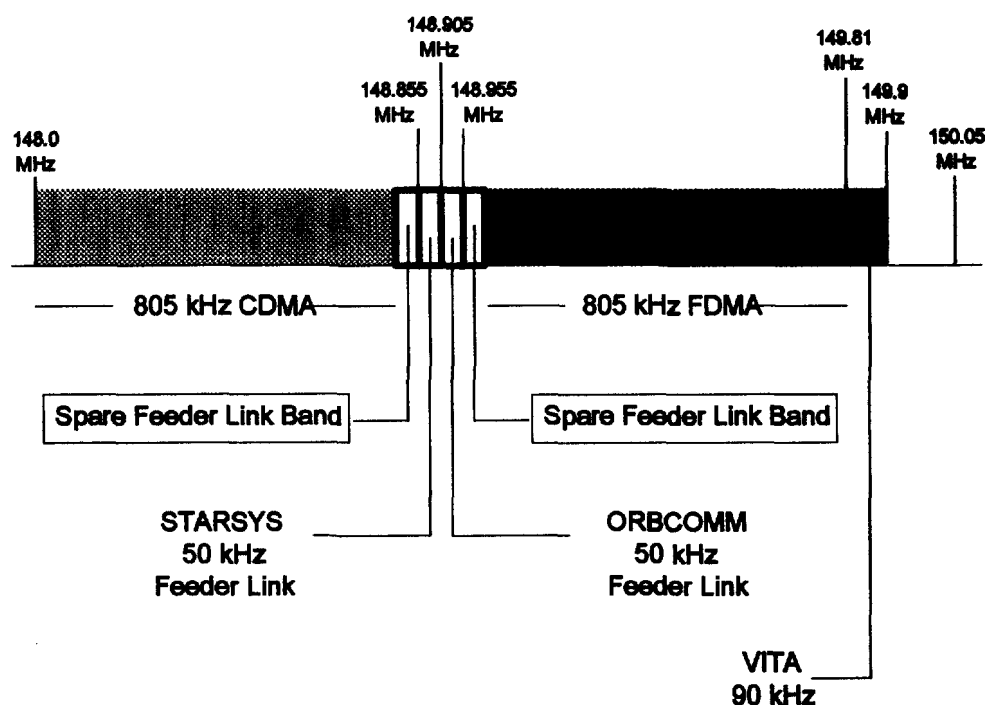


Figure A-3 - The "LEOAC-15" Spectrum Sharing Plan for the 148-150.05 MHz Band

As there is more bandwidth available in this band compared to the 137-138 MHz band, it is an obvious candidate for the additional accommodation of the relatively narrow-band feeder links for the LEO systems, as evidenced by the proposals from the existing applicants. For this

<sup>6</sup> This frequency sub-band does not in itself provide sufficient spectrum to support a commercially viable LEO system, and in any case will not become available until January 1997.

reason it is important that accommodation should also be made for some additional narrow-band feeder link channels to be used by future applicants. This could be achieved without seriously impacting the capacity of any of the existing licensees. Figure A-4 shows the proposed new spectrum plan with provision for two additional feeder links for future systems. Note that the wideband CDMA and FDMA regions of the band have been modestly reduced from 855 kHz to 805 kHz bandwidth, which will result in no more than a 6% reduction in the capacity of these segments.



**Figure A-4 - Proposed Spectrum Sharing Plan for the 148-150.05 MHz Band**

The ability of the CDMA part of the uplink band to accommodate multiple systems is determined, as before, by the aggregate power levels of the different users. However, in the case of the uplink, it is the mobile terminal EIRP areal-spectral density,  $e_{\text{m}}$ , that is the appropriate measure of operating power level, rather than the PFD. This approach to determining uplink capacity in CDMA systems was also adopted in the recent "Big Leo" NRM, and is the basis of the analysis presented below.

The aggregate mobile terminal EIRP areal-spectral density,  $e_{\text{m}}$ , is not explicitly stated in

EIRP of approximately 0 dBW, and ten such mobile transmitters are assumed to be able to transmit simultaneously (i.e., ten inbound channels in the original FCC application). The maximum aggregate mobile terminal EIRP is therefore +10 dBW. Assuming that this power is spread evenly over 805 kHz (which is an optimistic assumption because the spectrum amplitude is not constant across its occupied bandwidth), the resulting maximum aggregate EIRP spectral density would be -49 dBW/Hz, or -13 dBW/4kHz. Assuming that the users are distributed evenly over the STARSYS beam area (which is also an optimistic assumption), and that the STARSYS beam area is approximately  $2^{13} \text{ m}^2$  (or 133 dBm<sup>2</sup>), then the maximum aggregate EIRP areal-spectral density would be -146 dBW/m<sup>2</sup>/4kHz.

In order to determine where the STARSYS system is operating on the CDMA uplink capacity S-curve, the operating value of  $\epsilon_{\text{su}}$  (which was derived above to be -146 dBW/m<sup>2</sup>/4kHz) can be compared with the effective thermal noise equivalent uplink EIRP areal-spectral density in a 4 kHz bandwidth,  $\epsilon_{\text{nu}}$ . For a satellite system with a noise temperature of 500 K, the value of  $\epsilon_{\text{nu}}$  is -140 dBW/m<sup>2</sup>/4kHz. It would therefore appear that STARSYS is operating at approximately 6 dB below the equivalent thermal noise power level, which should provide adequate capacity for future entrants, ignoring the effects of external interference in this frequency band. This latter point is very important as the uplink interference problem in this band is potentially serious, and its effects cannot easily be incorporated into this analysis at this time. Further work is required to quantify the effects of this external interference.

In conclusion, it would be prudent for the Commission to constrain the STARSYS system to operate with a maximum aggregate EIRP areal-spectral density no greater than -140 dBW/m<sup>2</sup>/4kHz, to ensure that future entrants can be accommodated. Similarly, constraints concerning the CDMA code structure, as were made in relation to the 137 - 138 MHz band, are also important to the CDMA usage of this band.

In applying capacity and/or power level constraints to a CDMA system, the question always arises as to how such conditions can be verified in practice. In the case of the MSS NVNG LEO systems, this is particularly important because of the very large numbers of user terminals that will be deployed and the reliance on the time statistics of them accessing the system. The system operator must be able to both monitor and control the amount of traffic on the system to avoid possible system overloads that might occur. It should therefore be possible for the Commission to impose power level constraints that the operator can work within as a normal part of system operations.

In the case of a future FDMA system, it would be expected to share the 855 kHz band used by ORBCOMM for its mobile-to-satellite links. It is therefore of interest to understand

how much of this band ORBCOMM envisions using. The ORBCOMM Amended Application <sup>7</sup> proposes a Dynamic Channel Activity Assignment System (DCAAS) scheme to overcome the potential interference with terrestrial services, which makes use of a pool of 74 channels to derive 20 simultaneously usable channels. With each channel having an occupied bandwidth of 10 kHz, the pool of 74 channels requires 740 kHz from the available 855 kHz. This leaves only 115 kHz for future FDMA applicants, assuming that they cannot share the same pool of channels used by the ORBCOMM DCAAS scheme. Under these circumstances, there would clearly be insufficient capacity for a viable future FDMA licensee.

ORBCOMM has demonstrated its need for 74 available channels in Attachment 2 to its Amended Application. The analysis shows that ORBCOMM can achieve a probability of 99% of simultaneously finding 20 free channels out of a pool of 74. However, several assumptions concerning the characteristics of the interference environment are used in this derivation, and these are not supported by any rationale. ORBCOMM's availability results are plotted as a function of a parameter,  $k_{Ap}$ , which is the product of three variables, each an estimated function of the interfering system characteristics. ORBCOMM assumes that the parameter  $k_{Ap}$  may take any value between 0.1 and 1.6, and arbitrarily selects 0.8 to derive the 99% availability figure. If a value for  $k_{Ap}$  of 0.4 were assumed one could equally validly conclude that the probability of finding 20 free channels out of 74 is around 99.9%, or of finding 20 free channels out of 37 available channels is around 99%. The analysis method is such that it is not possible to conclude an absolute requirement for 74 channels, but rather one can conclude that this was the number of channels that was considered to be available to ORBCOMM at the time of the analysis. If the pool of channels was reduced to say 40 channels, there may well be negligible impact on the actual channel availability in practice.

In order to ensure that there is sufficient spectrum for future applicants, it would be prudent for the Commission to ensure that ORBCOMM be initially constrained to a pool of no more than 40 channels for mobile-to-satellite links in this frequency band, leaving approximately the same capacity for a future entrant. Alternatively, ORBCOMM should be constrained to ensure that its DCAAS scheme will be compatible with another similar dynamic channel assignment scheme operated by a different system, such that both systems can access the same common pool of channels without performance impairing conflicts.

---

<sup>7</sup> Orbital Communications Corporation (Amendment to Application, File No. 33-DSS-MP-90(20)), dated September 21, 1990.

### 2.3 399.9 - 400.05 MHz Band

None of the current applicants foresee using this frequency band which does not have

**APPENDIX B**

**ANALYSIS**

**OF**

**COORDINATION**

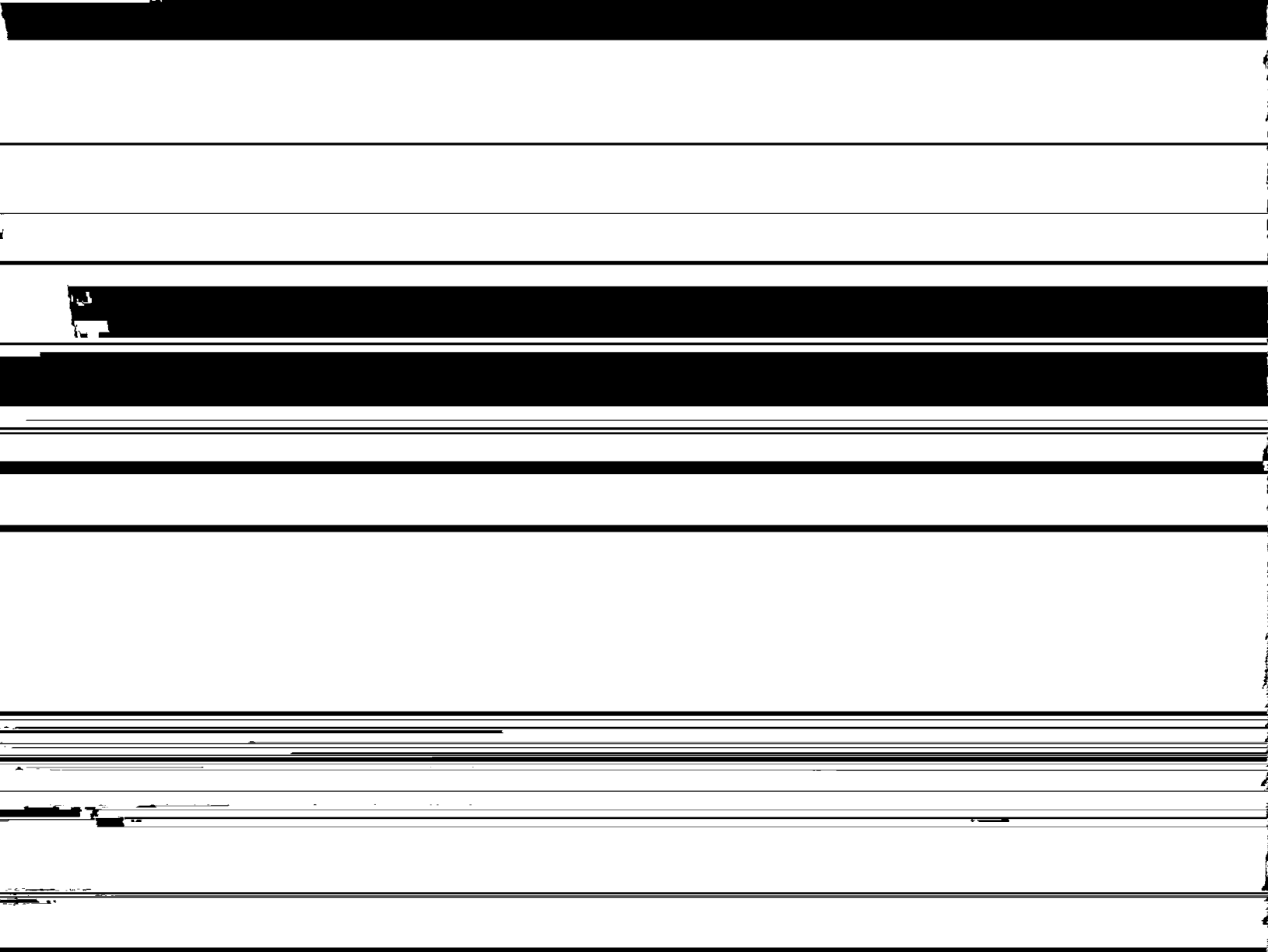
**PROCESS**



## **Technical Appendix B - Frequency Coordination Issues**

### **1. Introduction**

The Commission's NPRM relating to the NVNG MSS service <sup>1</sup> proposes two coordination requirements on the potential licensees. The first concerns the requirement to coordinate with Federal government users, via the Interdepartment Radio Advisory Committee (IRAC) of the NTIA. This coordination forum will be used to resolve the potential interference issues between the NVNG MSS service and other government users in the bands. The second requirement relates to the coordination between the various NVNG MSS licensees to resolve inter-system frequency coordination issues. It is this latter coordination which gives rise to



numerous satellites. The latter gives only limited isolation in the MSS environment, and does not permit full re-use in all cases.

The result of this situation is that frequency coordination in the LEO MSS service consists essentially of sharing the total spectrum resource that would have been available to a single system between the various competing systems. Such sharing can take the form of "interference sharing" in the case of CDMA systems, or by the avoidance of co-frequency

licensee to be completely intransigent and yet still claim compliance with the Commissions rules.

In the case of a new CDMA licensee, the measures that the new entrant would require to coordinate with the existing licensee on involve primarily the coding schemes and the power levels. Similarly, in the case of a new FDMA licensee, the issue during coordination would be primarily access to spectrum. Without some clear directive from the Commission at the outset, there is no reason why the existing licensees would bother to take account of a future competitor's requirements in any of these respects.

### **Problems Arising from a Confidential Coordination**

Generally, both domestic and international inter-system coordinations are dealt with on a confidential basis, with the only requirement being to report the success or otherwise to the responsible body (FCC in the case of domestic coordinations and ITU in the case of international coordinations). In the case of the FSS this is a rationale approach as there are no other parties that need to know the details of the coordination agreement that has been reached. However, in the case of the LEO MSS, any new entrant is seriously impacted by the existing usage of the band, which will be formalized in the coordination agreement between the existing licensees. A new entrant is not even in a position to make a judgement about the viability of making an application. If the Commission alone is in possession of the details of the existing coordination agreement, it would not, without a significant amount of work, be in a position to make a judgement on the viability of a new applicant's proposal. It is therefore of paramount importance in the LEO MSS service that all technical and operational matters embodied in the coordination agreement are made available to potential applicants before they make their application.

### **Conclusions**

Inter-system frequency coordination in the LEO MSS service presents new challenges to the regulatory authorities and new dangers to potential users of the frequency band. The particular situation in the NVNG MSS service is becoming critical as there is a serious risk of the Commission creating a duopoly by default unless it takes action now to protect the principles of multiple entry. The rules that must be created should limit the ability of the existing

## **APPENDIX C**

### **PROPOSED RULES**

## PROPOSED RULES

§ 25.142(a)(6)

If any additional frequency (e.g., in the 149.9-150.5 MHz or 399.9-400.5 MHz bands) becomes available for the non-voice.

- (ii) In the absence of mutual agreement during the coordination process referenced above, the operations of non-voice, non-geostationary mobile satellite service systems licensed under this section using Code Division Multiple Access ("CDMA") modulation will be limited to the default values of maximum downlink PFD spectral density of  $-164 \text{ dBW/m}^2/4\text{kHz}$  and maximum EIRP areal spectral density of  $-140 \text{ dBW/m}^2/4\text{kHz}$ . non-voice, non-geostationary mobile satellite service licensees using Frequency Division Multiple Access ("FDMA") modulation will default to approximately 80% of the currently assigned channels.
- (iii) In the case of non-voice, non-geostationary mobile satellite systems using code division multiple access techniques, operators shall use a coding system that includes sufficient numbers to accommodate future competitors.
- (iv) License conditions -- non-voice, non-geostationary mobile satellite service licenses shall be conditioned on the successful completion of coordination agreements with other non-voice, non-geostationary mobile satellite service licensees.

§ 25.142(c) **Reporting requirements.** All operators of non-voice, non-geostationary mobile satellite service systems shall file a semi-annual report (on February 1 and July 1 of each year) with the Common Carrier Bureau and the Commission's Laurel, Maryland field office containing the following information

- (1) Status of satellite construction and anticipated launch dates, including any major problems or delays encountered;
- (2) A listing of any non-scheduled space station outages for more than thirty minutes and the cause(s) of such outages;
- (3) A detailed description of the utilization made of the in-orbit satellite system. That description should identify the percentage of time that the system is actually used for domestic transmission, the amount of capacity in kBs (if any) sold but not in service, and the amount of used system capacity in kBs. These capacity determinations shall be made on a daily basis during each hour of the reporting period and shall be computed on an average and peak basis.

CERTIFICATE OF SERVICE

I, Robert A. Mazer, hereby certify that the copies of the foregoing Reply  
Comments of dbX Corporation were served by first-class mail, postage prepaid, this  
26th day of May 1993, on the following persons:

Albert Halprin  
Stephen L. Goodman  
Halprin, Temple & Goodman  
1301 K Street, N.W.  
Washington, D.C. 20005  
Counsel to Orbital Communications Corporation

Raul R. Rodriguez  
Stephen D. Baruch  
David S. Keir  
Leventhal, Senter & Lerman  
2000 K Street, N.W.  
Washington, D.C. 20006  
(202)429-8970  
Counsel to STARSYS Global Positioning, Inc.

Henry Goldberg  
Jonathan L. Wiener  
Goldberg, Godles, Wiener & Wright  
1229 Nineteenth Street, N.W.  
Washington, D.C. 20036  
(202)429-4900  
Counsel to Volunteers in Technical Assistance, Inc.

Dennis James Burnett  
Franceska O. Schroeder  
Haight, Gardner, Poor & Havens  
1300 I Street, N.W., Suite 470E  
Washington, D.C. 20005  
(202)962-3880  
Counsel to Space Technology Services International

Karen S. Muller  
1201 Pennsylvania Avenue, N.W.  
Suite 500  
Washington, D.C. 20004  
(202)626-6280  
Counsel to Leo One Corporation

  
Robert A. Mazer